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**ФАУНИСТИЧЕСКИЕ И ЭКОЛОГИЧЕСКИЕ ОСОБЕННОСТИ
СООБЩЕСТВ МЕЛКИХ МЛЕКОПИТАЮЩИХ ЗАПОВЕДНИКА
«ПЛАЮЛ ФАГУЛУЙ», РЕСПУБЛИКА МОЛДОВА**

**FAUNISTICS AND ECOLOGICAL PECULIARITIES
OF SMALL MAMMAL COMMUNITIES FROM "PLAIUL FAGULUI"
RESERVE, REPUBLIC OF MOLDOVA**

Исследования проводились в заповеднике «Плаюл Фагулуй» в центральной части Республики Молдова в 2011-2014 годах. В ходе исследования было зарегистрировано 26 видов мелких млекопитающих (7 видов насекомоядных и 19 видов грызунов). За все годы доминирующим видом был *A. agrarius* с более чем 33% из всех мелких млекопитающих, в то время как среди землероек наиболее распространенным был *S. araneus*. Значения индекса разнообразия Шеннона в весенний период варьировали между 0,3 и 0,85, а осенью между 0,6 и 1,1, причем самое низкое зарегистрировано в лесных экосистемах, а наибольшее во влажных биотопах. Наблюдалось общее увеличение индексов разнообразия в большинстве биотопов с начала периода исследования до 2014 года. Наибольшее сходство сообществ было зарегистрировано между обрабатываемыми полями, расположенными вблизи леса, и опушкой акациевого насаждения, а также между берегами водных бассейнов и влажными долинами. Анализ рарефакции указывает, что часть видового разнообразия еще не обнаружена. Мониторинг фауны мелких млекопитающих будет продолжаться.

The studies were performed in Plaiul Fagului reserve from the central part of the Republic of Moldova during 2011-2014 years. During the study 26 species of small mammals (7 insectivore and 19 rodent species) were registered in the reserve. In all the years the dominant species was *A. agrarius* with more than 33% of all small mammals, while among shrews the most abundant was *S. araneus*. The values of Shannon diversity index in spring period were comprised between 0.3 and 0.85 and in autumn between 0.6 and 1.1, the lowest being registered in forest ecosystems and the highest in wet biotopes. A general increasing of diversity indexes in most of biotopes from the beginning of study period to the last year was established. The highest similarity was registered between cultivated land situated near the forest and edge of acacia plantation, as well

as between shores of water basins and wet valleys. The rarefaction analysis indicates that a fraction of species diversity was not yet discovered. The monitoring of small mammal fauna will continue.

КЛЮЧЕВЫЕ СЛОВА. Заповедник, мелкие млекопитающие, сообщества, биотопы, динамика, разнообразие, сходство.

KEY WORDS. Reserve, small mammals, communities, biotopes, dynamics, diversity, similarity

Introduction

In modern conditions of anthropogenic changes nature reserves are important areas for the conservation of biodiversity and the survival of terrestrial vertebrate species. The Reserve «Plaiul Fagului» (Land of Beech) was established in 1992 and has an area of 5642 hectares. The most common types of trees are the oak — covers about 31% of the forest area, the ash tree — about 21%, hornbeam — about 19%. Although the share of beech accounts only 5%, it is most spread in this area, compared to the rest of the country.

The study of terrestrial vertebrate fauna in the area started in 50s-60s of the past century, where can be found data about some rodent species, such as representatives of Sciuridae and Gliridae families [10, 12]. In some papers and monographs are presented data on the biology and ecology of the mammals from the woods of central zone of the republic, including the territory of the reserve [11, 9]. The studies on fauna of the reserve were also performed after its creation for several years and have been summarized in the monograph «Nature of «Plaiul Fagului» Reserve» [2]. In the book 49 species of mammals are listed, of which 7 insectivorous and 21 rodent species [1]. The data on the presence of certain species in the ecosystems, their zoogeographical origin, criteria of rarity and some data on the biology of the species are given. Some general data on the fauna of small mammals were published later, where can be also found the characteristic of the reserve ecosystems. There is some information on the occurrence of shrew species in the reserve and forest ecosystems from the central zone of the republic, where 5 shrew species were described [6, 5]. The aim of this study was the analysis of small mammal communities, their seasonal dynamics in different types of biotopes, biotopic preferences, between year variation and complex ecological analysis of communities of insectivores and rodents in the reserve.

Material and methods

The studies were performed in spring (March-June) and autumn (end of August-November) periods of 2011-2014 in various types of biotopes on the territory of Plaiul Fagului reserve. The reserve is located in Ungheni district, at a distance of 70 km north-west from Chisinau city with coordinates N 47°18' and E 28°02'. The landscape is fragmented, with steep slopes and deep valleys, representing almost mountain landscape. The reserve belongs to geobotanical area of oak and beech forests and enters in the zone of deciduous forests. For studies there were selected the following types of ecosystems: forest, glades and clearings, forest edge, forest stands of pine and acacia, lake and river shores, cultivated lands, fallow grounds, wet valleys, ravines. Small mammals were caught with snap traps for 3 nights consecutively with a distance of 5 m between the traps [14]. Also, direct observa-

tion, counts on the route, sample plots were accomplished, traces and trophic activity of the animals were registered [13].

In ecological analysis of the data there were used the index of frequency, relative abundance to characterize the biotopic distribution of the species. The importance of certain taxonomic group in ecosystems was emphasized by calculating the ecological significance. The species of taxonomic groups with the significance less than 1% was considered accidental; 1,1 — 5% — accessorial; 5,1-10% — dominant and $W > 10\%$ — eudominant for the studied biocenosis. The diversity of small mammals was assessed by the Shannon and Simpson index. The species richness was evaluated using Margalef's index. The Berger-Parker index was used to evaluate the abundance of only the most abundant species in the population. The evenness analysis was used to represent the degree to which individuals are split among species.

In order to compare the communities from various biotopes the cluster analysis was performed. Rarefaction analysis was used to assess species richness in a given biotope. The statistical and factorial analyses, the graphic interpretation of the results were accomplished using the programs Microsoft Excel and BioDiversity Pro version 2.

Results and discussions

During the study 26 species of small mammals (7 insectivore and 19 rodent species) were registered in the reserve (tab. 1). The white-breasted hedgehog was recorded in all the studies biotopes by direct observation and after the traces of trophic activity, mostly after sunset and during the night. Its density constituted 0,6-1 ind./ha in forest biotopes, 1-2 ind./ha in glades and clearings, at forest edge, in shelter belts, in wet valleys and ravines and about 0.8 ind./ha near water bodies, in agricultural ecosystems and fallow grounds. The presence of the mole was registered by counting the mole-hills on a surface unit in various biotopes. Thus, its density constituted 1-2 ind./ha in woods, at forest edge, in shelter belts and 3-4 ind./ha in open type biotopes (ravines, valleys, fallow grounds, cultivated lands). It wasn't recorded in wet habitats or near water sources.

Among medium sized rodents the squirrel and the hazel dormouse were observed in all the biotopes with tree vegetation as eudominant and/or dominant species with a frequency of 72% and 48% respectively. The forest dormouse was recorded in forest biotopes and very seldom in forest belts, being dominant or accessorial species with a frequency of 36%. The fat dormouse (*Myoxus glis*) was observed in forest biotopes only, being the rarest species among dormouses with accessorial significance and frequency of 17%. It avoids open forest sectors, such as glades and clearings, the shelter belts and the forest edge (tab. 1).

The lesser mole rat (*Nannospalax leucodon*), recorded after its molehills, is eudominant and widespread in open type biotopes with a density of 3-4 ind./ha and frequency of 83%. It can be also met at forest edge and in shelter belts as accessorial species with a density of 0,7-2 ind./ha and frequency of 24%.

The hygrophilous species *Ondathra zibethicus* and *Arvicola terrestris* were registered exclusively near water basins with reed and sedge vegetation. The muskrat is a rather rare species with accessorial significance and frequency of 12% in aquatic habitats, while the water vole is a common species with dominant significance and frequency of 56%. The wild form of the brown rat was registered in the reserve near water basins and close to the buildings, such as fish farms, wild animal farms, ranger's household with dominant significance and frequency of 22% in natural biotopes and of 77% in farms and buildings.

Table 1

**Occurrence of small mammal species
in the studied biotopes of «Plaiul Fagului» reserve**

No	Species	Ecosystems								Rarity
		Forest	Glade	Forest edge	Shelter belts	Wet valley	Shore	Agroceen.	Fallow ground	
1	<i>Erinaceus concolor</i>	+	+	+	+	+	+	+	+	C
2	<i>Talpa europaea</i>	+	+	+	+	-	-	+	+	C
3	<i>Sorex araneus</i>	+	+	+	+	+	+	-	-	C
4	<i>S. minutus</i>	+	-	+	-	+	+	-	-	R
5	<i>Crocidura leucodon</i>	-	-	-	-	+	+	+	+	Cr
6	<i>C. suaveolens</i>	-	-	-	+	+	+	+	+	R
7	<i>Neomys anomalus</i>	+	-	-	-	+	+	-	-	VR
8	<i>Sciurus vulgaris</i>	+	+	+	+	-	-	-	-	C
9	<i>Myoxus glis</i>	+	-	-	-	-	-	-	-	R
10	<i>Dryomys nitedula</i>	+	+	+	-	-	-	-	-	C
11	<i>Muscardinus avellanarius</i>	+	+	+	+	-	-	-	-	C
12	<i>Nannospalax leucodon</i>	-	-	+	+	+	-	+	+	C
13	<i>Ondatra zibethicus</i>	-	-	-	-	-	+	-	-	R
14	<i>Arvicola terrestris</i>	-	-	-	-	-	+	-	-	C
15	<i>Rattus norvegicus</i>	-	-	-	-	+	+	-	-	C
16	<i>Mus musculus</i>	-	-	-	-	-	+	+	+	C
17	<i>M. spicilegus</i>	-	-	-	-	-	+	+	+	C
18	<i>Apodemus sylvaticus</i>	+	+	+	+	+	+	+	+	C
19	<i>A. uralensis</i>	-	+	+	+	+	+	+	+	C
20	<i>A. flavicollis</i>	+	+	+	+	+	+	+	-	C
21	<i>A. agrarius</i>	+	+	-	+	+	+	+	-	C
22	<i>Micromys minutus</i>	-	-	-	-	-	+	-	-	VR
23	<i>Microtus arvalis</i>	-	-	-	-	-	-	+	+	C
24	<i>M. rossiaemeridionalis</i>	-	-	-	+	+	+	-	+	C
25	<i>Clethrionomys glareolus</i>	+	+	+	+	+	+	-	-	C
26	<i>Pitymys subterraneus</i>	+	-	-	-	-	-	-	-	R

C-common, R-rare, VR-very rare, Cr-critically endangered

Small mammal communities were assessed according to captures in snap traps. During four years of captures 8 rodent and 4 insectivore species were registered. In all the years the dominant species was *A. agrarius* with more than 33% of all small mammals, due to the presence of many wet biotopes and acacia stands, which are preferred by this species. The increasing of this species frequency and significance in the last years was recorded previously in various forest, as in other types of biotopes [8]. The second species after its abundance was *C. glareolus* (18.4%), a forest species, registered in most of the studied biotopes. The wood mouse (16.7%) and the yellow-necked mouse (about 13%) were also found with rather high abundance. The vole of genus *Microtus* were recorded in open biotopes and in cultivated lands with more than 10%. The species of genus *Mus* and *A. uralensis* were registered in low number (fig. 1).

Among shrews the most abundant was *S. araneus* (3.9%), followed by *C. suaveolens* (0.8%) and *S. minutus* (0.7%). The lowest abundance had *C. leucodon*, which is a vulnerable species, listed in the Red Book of Moldova.

All shrew species were recorded in wet biotopes, such as wet valleys, swamp habitats, lake and river shores, the *Sorex* species being eudominant, *Crocidura* species — dominant and *Neomys anomalus* — accidental. In forest ecosystems the common shrew is widespread with dominant significance and frequency of 89%, while the pigmy shrew was found only in swamp sectors of the forest and at forest edge with accessorial significance and lower frequency (37%). Similar values of frequency and ecological significance were found for these species in other forest ecosystems of the republic [3]. *Sorex* species weren't registered in agrocenoses and fallow grounds, while both *Crocidura* species, which are less hygrophilous, were present with dominant significance and frequency of 12.7% for *C. leucodon* and 26.3% for *C. suaveolens*. Although, the white toothed shrew is a critically endangered species, included in the Red Book of Moldova, its ecological significance and frequency increased in the last years in forest ecosystems [5], as well as in other types of biotopes [5, 6]. As to the Mediterranean water shrew,

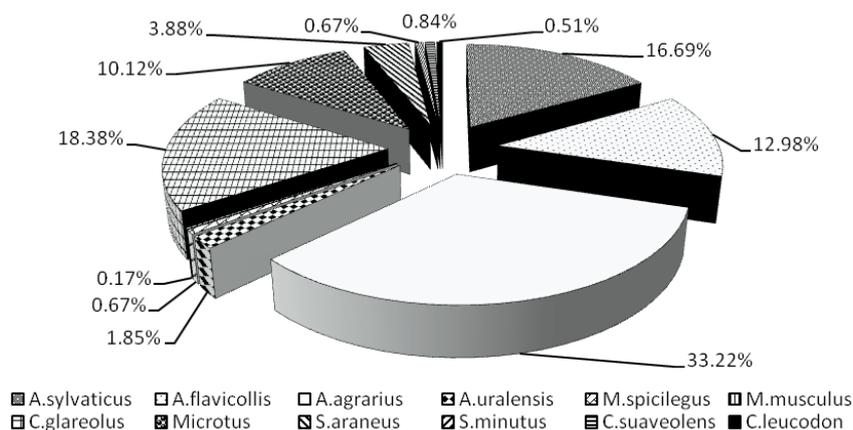


Figure 1. Abundance of small mammals' community in the reserve during the study period

its ecological significance and frequency decreased drastically in the last years all over the territory of the republic and the species become very rare and endangered. In the reserve the Mediterranean water shrew was recorded only one time during the years of study even in its preferred habitats, where it was registered before [1, 4, 6, 7].

The analysis of seasonal dynamics showed a much lower diversity in spring than in autumn period (fig. 2). Thus, the values of Shannon diversity index in spring period were comprised between 0.3 and 0.85, the lowest being registered in forest ecosystems (wood, forest belts, plantations) with 2 species and the highest in wet biotopes (wet valleys, shore of lakes and rivulets) with 7 species. In autumn the diversity index varied between 0.6 and 1.1 with the lowest one in forest ecosystems (4 species) and the highest in wet biotopes, where all 12 species of rodents and shrews were registered.

The biotopic distribution of the species in both season during the studied years varied greatly. In forest biotopes dominated the sylvicolous species (*A. flavicollis* and *C. glareolus*) and in autumn period individuals of *A. sylvaticus* and *A. agrarius* were also found. At forest edge the species diversity was much higher, being registered 6 species in spring and 8 species in autumn. The community was represented both by typically sylvicolous species and by open land species, such as *A. uralensis* and *M. rossiaemeridionalis*, while *A. sylvaticus* dominated in both periods. The wet biotopes were the most rich quantitatively and qualitatively in both study periods, with the dominance of hygrophilous species *A. agrarius*, while the proportion of shrews reached more than 36% in spring and about 10% in autumn. In various types of agrocenoses 5 species were registered in spring and 8 species in autumn. Because the cultivated lands were situated near the wood, typically sylvicolous species (*A. flavicollis*) were registered along with species typical for agroecosystems (*Mus* and *Microtus* species). Also shrew from genus *Crocidura* that inhabit open and cultivated lands, were recorded (fig. 2).

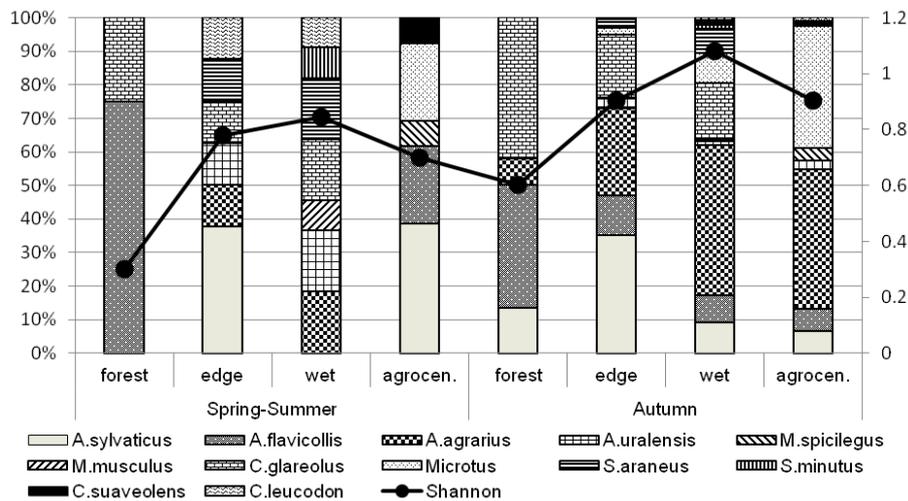


Figure 2. Diversity and biotopic distribution of small mammals in the reserve during the study period

The multiannual dynamics of small mammal communities in autumn period was analyzed, when the density of small mammals is the highest. The climatic conditions in the studied years were different: in 2011 the weather was very hot and the amount of precipitations was much lower than usual, in 2012 was a very hot and dry summer, then a rainy autumn; while 2013-2014 were within the normal limits of temperature and amount of precipitations. Also, the population phases of small mammal species were different: in 2011 a depression of rodents' number was registered, in 2012 started the number increase that reach its maximum in 2014. Therefore, in 2011 a year with rodent depression and difficult climatic conditions only 5 species were recorded in forest biotopes and at their edges, 6 species in wet habitats and only 2 in agroecosystems, of which the eurytopic species *A. sylvaticus* was dominant in most of biotopes, except the wet one, where *A. agrarius* dominated (fig. 3). In 2012 the species number increased to 9 species in wet ecosystems and 6 species in cultivated lands and fallow grounds. In forest ecosystems dominant was *A. flavicollis*, while in other types of ecosystems — *A. agrarius*, due to abundant precipitations in autumn period. The shrew community was represented by 3 species and constituted about 13% in wet ecosystems (fig. 3).

In 2013 an increase of vole species population was registered, *C. glareolus* being dominant in forest ecosystems and at edges, and *Microtus* species — in agroecosystems and fallow grounds. In wet biotopes *A. agrarius* remain the dominant species. Also, a high depression of shrew populations' was recorded in 2013, which was represented only by *S. araneus* and only in wet habitats (less than 2%). In 2014 the highest diversity and abundance of shrew species was registered that constituted almost 14% from the whole community in forest ecosystems and 17% in wet habitats. In forest biotopes *A. flavicollis* was dominant, at the edge and in wet biotopes *A. agrarius* dominated, while in agroecosystems *Microtus* species remain dominant (fig. 3).

After analyzing the species structure of small mammal communities during the study years, it can be seen the highest diversity in wet habitats and a general increasing of diversity indexes (Shannon, Simpson) in most of biotopes from the beginning of study period to the last year (tab. 1). The species richness, evaluated

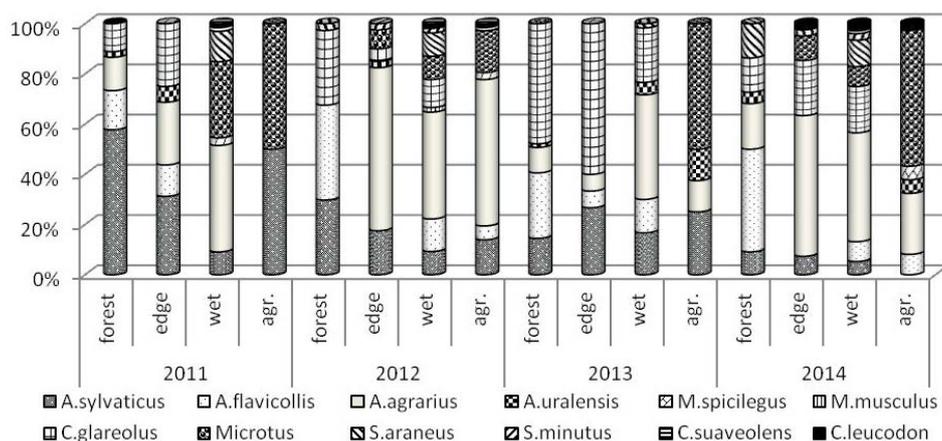


Figure 3. Multiannual dynamics of small mammals in various types of ecosystems in the studied years

according to Margalef index, increased for the same period, the maximum values being registered on the account of more rare shrew species. The Berger-Parker index reports the proportional abundance of only the most abundant species in the population. Thus, it was the highest in the biotopes where 2-3 species dominated and constitute more than 70% of the community (tab. 2).

The evenness analysis showed low values at the forest edge and in agrocenoses (in 2012 and 2014) indicating that one or two species dominate, and the highest values in agrocenoses and at forest edge in 2011, where few species were represented almost equally.

The similarity of small mammals' communities in various types of biotopes was performed using the Cluster analysis (fig. 4). Thus, among 12 types of biotopes the

Table 2

Indexes of diversity and species richness in the reserve during 4 years of study

Years	2011				2012				2013				2014			
	f.	f.e.	wet	agr.	f.	f.e.	wet	agr.	f.	f.e.	wet	agr.	f.	f.e.	wet	agr.
Shannon	1.2	1.49	1.41	0.69	1.19	1.11	1.76	1.25	1.28	1.02	1.48	1.21	1.58	1.26	1.71	1.29
Simpson domin.	0.39	0.24	0.29	0.5	0.32	0.46	0.24	0.39	0.33	0.44	0.27	0.34	0.25	0.38	0.25	0.36
Simpson diversity	2.57	4.13	3.37	2	3.12	2.16	4.21	2.55	3.05	2.27	3.72	2.91	4.03	2.64	3.99	2.74
Margalef	6.65	9.14	7.24	18.27	7.01	6.87	6.35	7.07	5.98	9.35	6.19	12.18	8.19	6.82	5.85	7.01
Berger-Parker	0.58	0.31	0.42	0.5	0.38	0.65	0.43	0.58	0.48	0.6	0.42	0.5	0.41	0.56	0.43	0.54
Evenness	0.75	0.93	0.79	1	0.86	0.62	0.79	0.69	0.79	0.74	0.83	0.87	0.88	0.7	0.78	0.72

Note: f.-forest ecosystems, f.e.-forest edge, agr.-cultivated lands and fallow ground

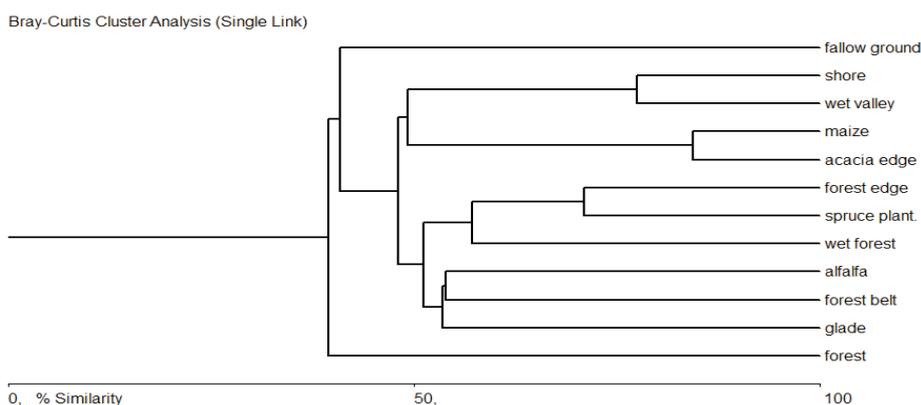


Figure 4. Similarity analysis of small mammal communities in the reserve during the study period

highest similarity (84.37%) was registered between maize field situated near the forest and edge of acacia plantation, where most of species were common and the species ratio was similar. The communities from shores of rivulets and lakes were similar to those from wet valleys (77.57%) where 8 species were common and their proportion was similar. Rather high similarity value was found between forest edge and spruce plantation (70.97%). The similarity between the other of biotopes was lower than 60%. The lowest similarity was registered between fallow ground and the rest of biotopes (up to 40%) and between forest and other biotopes (up to 48%).

In order to assess species richness, e.g. the expected number of species against the number of individuals, the rarefaction analysis was performed (fig. 5). The most of curves are rising and represent steep slopes, which indicate that a fraction of species diversity was not yet discovered. This situation can be observed in most of biotopes, but is more pronounced at shores of lakes and rivulets, where the species richness and individual number was the highest and a part of community wasn't yet assessed. In forest and glade biotopes the curves become flatter, which means that a reasonable number of individual samples have been taken and more intense sampling will show only few additional species.

Thus, during the study period an increase of diversity and number in small mammal communities was registered, conditioned mostly by rare shrew species, which were most abundant and diverse in the last year of study, when the climatic conditions were also favorable.

The reserves represent important areas of species diversity conservation, with much lower anthropic disturbances than in adjacent territories. The existence of a high variety of habitats ensure the existence and prosperity of small mammals populations, as well as a stable balance of ecosystem functioning. Therefore, the monitoring of small mammal communities in the reserve will continue in order to compare their evolution in natural conditions of the reserve with that from anthropized territories, as well as for elucidate the population cycles of the species and the influence of climatic conditions upon small mammal communities.

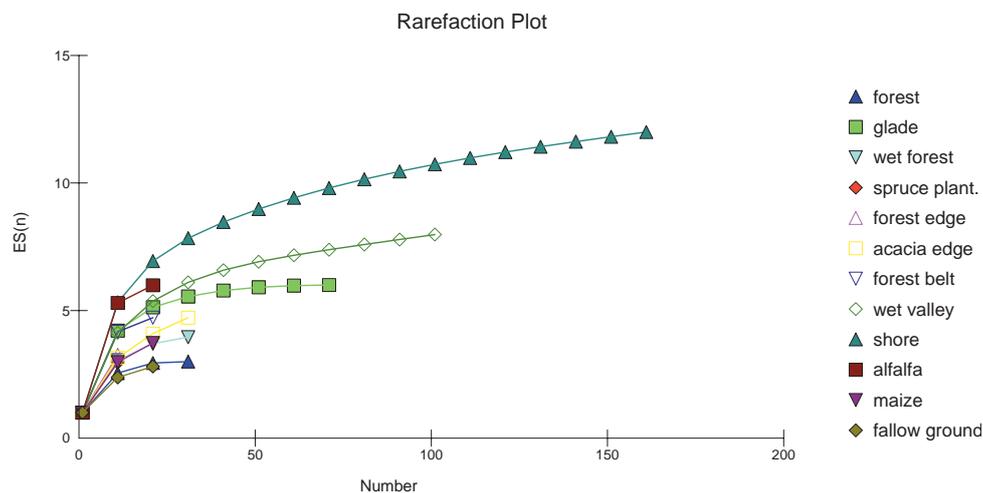


Figure 5. Rarefaction curves for studied biotopes in the reserve

Conclusions

During the study 26 species of small mammals (7 insectivore and 19 rodent species) were registered in the reserve. In all the years the dominant species was *A. agrarius* with more than 33% of all small mammals, while among shrews the most abundant was *S. araneus*.

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